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EVALUATION OF COMMERCIAL ANTIFREEZES.(U)

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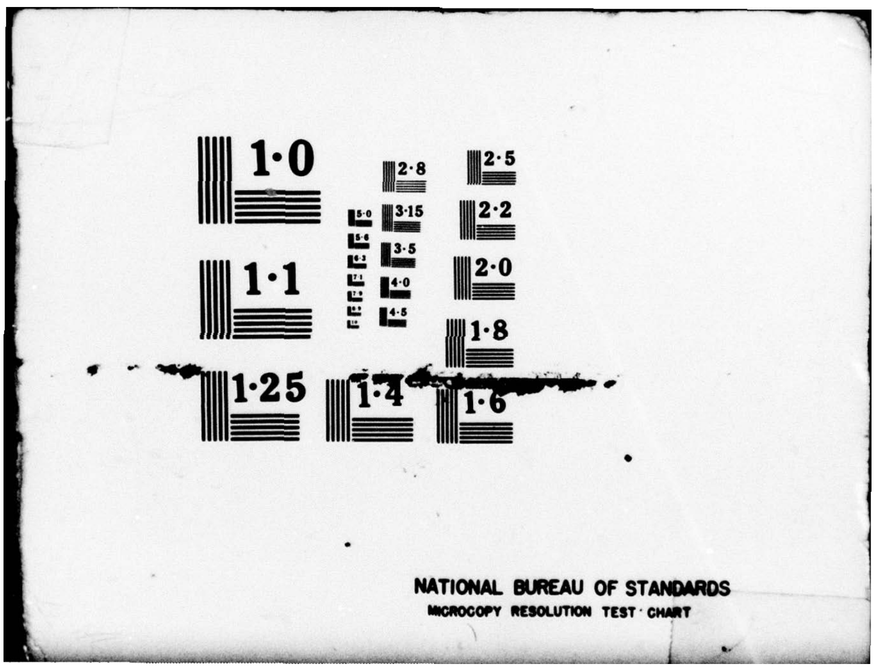
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Report 2248

# EVALUATION OF COMMERCIAL ANTIFREEZES

by


James H. Conley
Robert G. Jamison


May 1978



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U.S. ARMY MOBILITY EQUIPMENT
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The object of this study was to investigate the potential of corrosion problems when commercial antifreezes are mixed between themselves or with the military antifreeze MIL-A-46153.

Results show that even though some commercial antifreezes give adequate corrosion protection by themselves, mixtures are less than adequate. In most instances the mixtures corrode one or more of the common cooling system metals.

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## TABLES

# EVALUATION OF COMMERCIAL ANTIFREEZES

## I. INTRODUCTION

In recent years, the trend has been for the Army to purchase commercial vehicles. These vehicles are covered by the manufacturer's warranties which require the use of specified expendable materials. One such material is antifreeze.

Each vehicle manufacturer recommends the use of a particular product, usually covered by his own specification. Equipment failure resulting from the use of a product not recommended by the manufacturer will negate the warranty. In every case, the judgment is made by the vehicle manufacturer.

Most antifreeze compounds are compatible with each other from the standpoint of solubility; e.g., there is no precipitation of inhibitors when two different antifreezes are mixed. Occasionally there are materials that visibly interact and form precipitates, but this is only one aspect of antifreeze compatibility. Blends which show no precipitation during or after mixing may yet react with one another and form soluble compounds that are corrosive to the cooling system metals.

True compatibility can be verified only by a corrosion test such as the ASTM-D-1384, Glassware Corrosion Test for Engine Coolants. This test also correlates with the simulated service test ASTM-D-2570. Obviously, the number of possible concentration ratios of two or more antifreeze fluids is infinite and actual tests have to be limited to a reasonable number of mixtures.

Several commonly supplied Original Equipment Manufacturer (OEM) antifreezes and commercial antifreezes were selected to determine compatibility with each other and with the Army's MIL-A-46153 in terms of corrosiveness, changes in reserve alkalinity (RA), and changes in acidity (pH) as these are the more important property aspects of antifreeze mixtures.

## II. DETAILS OF TEST

All tests were conducted according to ASTM Method D-1384, Corrosion Test for Engine Coolants in Glassware. This method describes a simple breaker test for evaluating the corrosion effects of engine coolants on metal specimens. Metal specimens, typical of those present in automotive cooling systems, are totally immersed in the test antifreeze solution with aeration for 336 hours at 88° C (190° F). The corrosion inhibitive properties of the test solution are evaluated on the basis of the weight changes incurred by the specimens. Each test is run in triplicate and the average weight change is determined for each metal.

Tests on mixed antifreezes utilized two components in equal parts by volume diluted to 33-1/3 percent by volume with ASTM corrosive water containing 100 p/m each of chloride, sulfate, and bicarbonate.

Values for reserve alkalinity (RA) and acidity (pH) were measured both before and after the corrosion tests. Reserve alkalinity of new antifreeze is used in production quality control and in specifications to indicate the amount of alkaline (basic) inhibitors present in the product. Similarly, the reserve alkalinity of used solutions is a measurement that indicates the amount of remaining alkaline inhibitors in coolant performance testing. The pH of a solution is commonly considered to be the negative logarithm (to the base 10) of the hydrogen ion concentration and is not a dependable indication of either existing effectiveness or remaining life of a solution. Both reserve alkalinity and pH measurements are effective in determining the presence of a buffer. A buffer is any substance or combination of substances which when dissolved in water produces a solution which resists a change in its hydrogen ion concentration upon the addition of acid or alkali. A considerable number of antifreezes including MIL-A-46153 rely upon a buffer-type inhibitor for corrosion protection.

## III. DISCUSSION OF RESULTS

Table 1 shows the comparison of corrosion test results of three OEM (factory fill) antifreezes (codes A, B, and C) and six commercial antifreezes manufactured by chemical companies (codes D through J) with MIL-A-46153. Only one commercial antifreeze (code E) meets the corrosion requirements. None of the nine commercial materials tested "good" with the Army's reserve alkalinity test strip. Reserve alkalinity values from 8 to 10 indicate "good," 6 to 8 indicate "borderline," and 4 to 6 indicate "poor; change coolant." Eight of the commercial antifreezes show "borderline" and one shows "poor; change coolant," all of which fail the Military specification requirement for reserve alkalinity.

Table 2 shows the corrosion test results of 12 binary mixtures of commercial antifreezes. Eight of the mixtures, including mixtures of the three OEM materials, fail the requirements for weight loss on one or more of the six cooling system metals. All 12 of the blends test as "borderline" with the reserve alkalinity test strip and do not pass the Military specification requirements.

Table 3 displays the corrosion test data of nine binary blends of commercial antifreezes with MIL-A-46153. Five out of the nine mixtures fail the corrosion weight loss limits. All of the mixtures test as "borderline" with the reserve alkalinity test strip and again fail the MIL-A-46153 specification requirements.

Table 4 summarizes the antifreezes and mixtures that meet the weight loss limits of MIL-A-46153.

Table 1. Weight Loss Comparison of OEM/Commercial Antifreezes and MIL-A-46153 Antifreeze with Maximum Weight Loss Limits

| | | Weight Loss per Specimen (mg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test No. | Antifreeze | Copper | Solder | Brass | Steel | Cast Iron | Cast Al | Init pH | Final pH | Init RA | Final RA |
| 1 | A[1] | 12.05[3] | 22.85 | 10.9[3] | 1.8 | 1.4 | 0.4 | 10.25 | 9.8 | 7.1 | 6.6 |
| 2 | B[1] | 10.6[3] | 19.0 | 15.6[3] | 2.8 | 1.6 | 4.8 | 8.9 | 8.8 | 6.6 | 5.9 |
| 3 | C[1] | 13.2[3] | 21.8 | 17.4[3] | 2.2 | 1.1 | 9.6 | 9.2 | 9.15 | 7.5 | 6.7 |
| 4 | D[2] | 8.9 | 31.3[3] | 10.8[3] | 2.4 | 2.0 | 7.8 | 9.8 | 8.75 | 3.7 | 3.55 |
| 5 | E[2] | 9.9 | 20.7 | 8.8 | 2.9 | 0.5 | 0.6 | 10.65 | 9.5 | 7.4 | 6.3 |
| 6 | F[2] | 10.9[3] | 16.6 | 6.3 | 0.5 | 0.13 | 27.4 | 9.55 | 9.3 | 7.6 | 7.4 |
| 7 | G[2] | 11.2[3] | 15.3 | 8.9 | 2.4 | 1.3 | 10.0 | 9.9 | 8.8 | 6.5 | 6.0 |
| 8 | H[2] | 8.6 | 31.3[3] | 9.7 | 2.2 | 0.4 | 2.3 | 8.45 | 8.23 | 6.9 | 6.6 |
| 9 | J[2] | 10.2[3] | 11.55 | 9.1 | 0.2 | +0.65 | 3.9 | –[4] | 9.6 | –[4] | 7.6 |
| 10 | MIL-A-46153 | 7.3 | 2.5 | 8.6 | 3.2 | 0.6 | 17.2 | 8.0 | 7.6 | 8.9 | 8.9 |
| Max weight loss limit | | 10.0 | 30.0 | 10.0 | 10.0 | 10.0 | 30.0 | | | | |

1 Original Equipment Material (OEM) supplied by vehicle manufacturer.
2 Commercial antifreeze produced by chemical company.
3 Exceeds weight loss limits.
4 No values.

Table 2. Weight Loss Comparison of Binary OEM/Commercial Antifreeze Mixtures with Maximum Weight Loss Limits

| | | Weight Loss per Specimen (mg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test No. | Mixtures 50% by Vol | Copper | Solder | Brass | Steel | Cast Iron | Cast Al | Init pH | Final pH | Init RA | Final RA |
| 1 | A/B | 12.4* | 24.4 | 13.3* | 0.9 | 0.9 | 1.7 | 9.5 | 9.25 | 7.0 | 6.5 |
| 2 | A/C | 12.6* | 28.1 | 12.2* | 0.7 | 0.0 | 0.1 | 9.9 | 9.4 | 7.2 | 6.5 |
| 3 | B/C | 12.4* | 22.6 | 15.6* | 0.7 | 1.3 | 5.7 | 8.9 | 8.85 | 6.7 | 6.0 |
| 4 | D/H | 4.9 | 23.1 | 6.7 | 1.6 | 1.3 | 19.2 | 8.6 | 8.55 | 5.9 | 5.8 |
| 5 | D/F | 10.1* | 19.5 | 11.3* | 2.4 | 2.1 | 12.5 | 9.2 | 8.65 | 6.2 | 6.2 |
| 6 | E/F | 9.8 | 29.3 | 12.3* | 2.6 | 0.7 | 0.0 | 10.0 | 9.3 | 7.4 | 6.5 |
| 7 | E/G | 8.1 | 2.6 | 9.2 | 2.0 | 0.5 | 1.0 | 10.3 | 9.3 | 6.8 | 4.6 |
| 8 | E/H | 9.2 | 28.8 | 9.9 | 6.8 | 0.6 | 2.8 | 8.8 | 8.62 | 7.2 | 5.9 |
| 9 | F/H | 11.1* | 27.1 | 11.2* | 1.9 | 0.7 | 14.4 | 8.75 | 8.57 | 7.2 | 6.7 |
| 10 | G/H | 10.5* | 39.1* | 11.5* | 2.7 | 1.3 | 2.2 | 8.7 | 8.48 | 6.9 | 6.3 |
| 11 | F/G | 10.2* | 31.7* | 12.2* | 7.2 | 0.95 | 5.6 | 9.75 | 9.2 | 6.9 | 6.1 |
| 12 | F/J | 3.9 | 16.9 | 8.1 | 0.6 | +1.3 | 5.4 | – | 9.3 | – | 6.2 |
| Max weight loss limit | | 10.0 | 30.0 | 10.0 | 10.0 | 10.0 | 30.0 | | | | |

* Exceeds weight loss limit.

Table 3. Weight Loss Comparison of Binary Mixtures of Various OEM/Commercial Antifreezes and MIL-A-46153 with Maximum Weight Loss Limits

| | | Weight Loss per Specimen (mg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test No. | Mixtures 50% by Vol | Copper | Solder | Brass | Steel | Cast Iron | Cast Al | Init pH | Final pH | Init RA | Final RA |
| 1 | A/46153 | 16.3* | 24.6 | 12.8* | 3.3 | 1.0 | 4.3 | 8.2 | 7.75 | 7.1 | 6.8 |
| 2 | B/46153 | 13.8* | 20.9 | 14.3* | 2.1 | 1.7 | 5.8 | 8.0 | 7.6 | 7.2 | 5.9 |
| 3 | C/46153 | 10.1* | 25.7 | 13.2* | 2.3 | 1.7 | 2.4 | 8.0 | 7.55 | 7.4 | 7.3 |
| 4 | D/46153 | 10.1* | 18.5 | 8.6 | 2.4 | 1.2 | 24.4 | 7.9 | 7.9 | 6.9 | 6.9 |
| 5 | E/46153 | 8.6 | 26.2 | 9.2 | 1.9 | 0.8 | 1.8 | 8.4 | 8.25 | 7.4 | 6.1 |
| 6 | F/46153 | 7.2 | 22.4 | 8.5 | 1.1 | 1.5 | 9.5 | 8.4 | 8.3 | 7.5 | 7.1 |
| 7 | G/46153 | 6.4 | 23.7 | 7.9 | 1.3 | +1.1 | 10.8 | 8.4 | 7.9 | 6.5 | 6.5 |
| 8 | H/46153 | 10.8* | 27.8 | 9.8 | 6.7 | 0.2 | 3.1 | 8.25 | 8.05 | 6.9 | 6.3 |
| 9 | J/46153 | 7.9 | 17.3 | 8.4 | 0.45 | +1.8 | 5.9 | – | 8.2 | – | 7.8 |
| Max weight loss limit | | 10.0 | 30.0 | 10.0 | 10.0 | 10.0 | 30.0 | | | | |

* Exceeds weight loss limits.

Table 4. Summary of Results

| Antifreezes and Mixtures Meeting Weight Loss Limits | | |
|---|---|---|
| OEM/Commercial | OEM/Commercial Binary Mixtures | OEM/Commercial and MIL-A-46153 |
| Code E | D/H | E/46153 |
| (1 of 9) | E/G | F/46153 |
| | E/H | G/46153 |
| | F/J | J/46153 |
| | (4 of 12) | (4 of 9) |

## IV. CONCLUSIONS

From the results listed in this study, it is evident that serious problems are likely to evolve if commercial antifreezes or OEM antifreezes are mixed with each other, or with MIL-A-46153. It is also clear that use of these mixtures will render the reserve alkalinity field test kit unusable, leaving the troops in the field with no method of adequately maintaining their vehicle cooling system.

The use of OEM or commercial antifreeze in Military vehicles is not recommended. In the instances where a vehicle warranty includes the use of an antifreeze other than MIL-A-46153, only the manufacturers' recommended antifreeze should be used during the warranty period. Immediately after expiration of the warranty period, the system should be drained, flushed, and refilled with MIL-A-46153 antifreeze only.

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